authenticate the voiced command using the detection. The authentication of the voiced command may include detecting a correlation between the voiced command of the user and a voice pattern of the user detected in the skin deformation information.

[0014] In some embodiments, the device may be an earbud that includes an in-ear speaker and a radio transmitter. The device may transmit the voiced command using the radio transmitter upon authentication of the voiced command.

[0015] In some embodiments, the device may be a headphone, and the location on the user's head may be proximate to at least one of a temporal bone and the parietal bone of the user. The device may transmit the voiced command using the radio transmitter upon authentication of the voiced command.

[0016] Also described herein is a device that may include: a head-mountable frame configured to be worn by a user; a self-mixing interferometry sensor mounted to the head-mountable frame and operable to emit a beam of light toward a location on the user's head; a microphone configured to produce an audio signal; and an audio conditioning circuit configured to modify the audio signal using a self-mixing interferometry signal of the self-mixing interferometry sensor.

[0017] In any or all of these various embodiments, the beam of light may be produced by a laser diode. The various embodiments may use a time-domain I/Q analysis of the self-mixing interferometry signal. Such a time-domain I/Q analysis includes applying a sine wave modulation to the laser diode's bias current. Alternatively or in conjunction, the various embodiments may use a spectrum analysis of the self-mixing interferometry signal when a triangle wave modulation is applied to the laser diode's bias current. In yet another implementation, a constant (D.C.) driving of the laser diode's bias current may also be used.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The disclosure will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements.

[0019] FIG. **1** illustrates a self-mixing interferometry sensor emitting a coherent light beam at a location on a head of a user, according to an embodiment.

[0020] FIG. **2**A illustrates a block diagram of the components of a wearable device, in relation to part of a user's head, according to an embodiment.

[0021] FIG. **2**B illustrates a block diagram of the components of another wearable device, in relation to part of a user's head, according to an embodiment.

[0022] FIG. **2**C illustrates a block diagram of the components of a third wearable device, in relation to part of a user's head, according to an embodiment.

[0023] FIG. **3**A illustrates an ear bud that may use skin deformation or skin vibration detection, according to an embodiment.

[0024] FIG. **3**B illustrates a headphone apparatus with a component for detecting skin deformation, or skin vibration or movement, according to an embodiment.

[0025] FIG. **4**A illustrates a VCSEL diode with an integrated intra-cavity photodetector, according to an embodiment.

[0026] FIG. **4**B illustrates a VCSEL diode associated with a separate photodetector, according to an embodiment.

[0027] FIG. **4**C illustrates a VCSEL diode with an extrinsic, on-chip photodetector, according to an embodiment.

[0028] FIG. **4**D illustrates a VCSEL diode with an extrinsic, off-chip photodetector, according to an embodiment.

[0029] FIG. **5** shows time-correlated graphs of a self-mixing interferometry signal and a corresponding short-time Fourier transform during voiced speech, according to an embodiment.

[0030] FIG. **6** shows time-correlated graphs of a self-mixing interferometry signal and a corresponding short-time Fourier transform during silent jaw motion, according to an embodiment.

[0031] FIG. **7**A illustrates a schematic for a self-mixing interferometry light source, according to an embodiment.

[0032] FIG. **7**B illustrates self-mixing of laser light, according to an embodiment.

[0033] FIG. **7**C illustrates a variation in an interferometric parameter due to self-mixing, according to an embodiment.

[0034] FIG. **8**A is a flow chart of a spectrum analysis method for determining distances from a light source to an object using self-mixing interferometry, according to an embodiment.

[0035] FIG. **8**B shows time-correlated graphs of signals that may occur in a self-mixing interferometry sensor, according to an embodiment.

[0036] FIG. **8**C illustrates a block diagram of a circuit operable to implement the spectrum analysis method for determining distances from a light source to an object using self-mixing interferometry, according to an embodiment.

[0037] FIG. **9**A is a flow chart of a time domain method for determining distances from a light source to an object using self-mixing interferometry, according to an embodiment.

[0038] FIGS. **9**B-C show time-correlated graphs of signals that may occur in a self-mixing interferometry sensor, according to an embodiment.

[0039] FIG. **10** illustrates a block diagram of a circuit operable to implement the time domain method for determining distances from a light source to an object using self-mixing interferometry, according to an embodiment.

[0040] FIG. **11** illustrates a block diagram of an electronic device that is configured to detect user input, according to an embodiment.

[0041] The use of cross-hatching or shading in the accompanying figures is generally provided to clarify the boundaries between adjacent elements and also to facilitate legibility of the figures. Accordingly, neither the presence nor the absence of cross-hatching or shading conveys or indicates any preference or requirement for particular materials, material properties, element proportions, element dimensions, commonalities of similarly illustrated elements, or any other characteristic, attribute, or property for any element illustrated in the accompanying figures.

[0042] Additionally, it should be understood that the proportions and dimensions (either relative or absolute) of the various features and elements (and collections and groupings thereof) and the boundaries, separations, and positional relationships presented therebetween, are provided in the accompanying figures merely to facilitate an understanding of the various embodiments described herein and, accordingly, may not necessarily be presented or illustrated to scale, and are not intended to indicate any preference or